Environmental Justice Issues of the North Carolina Swine Industry

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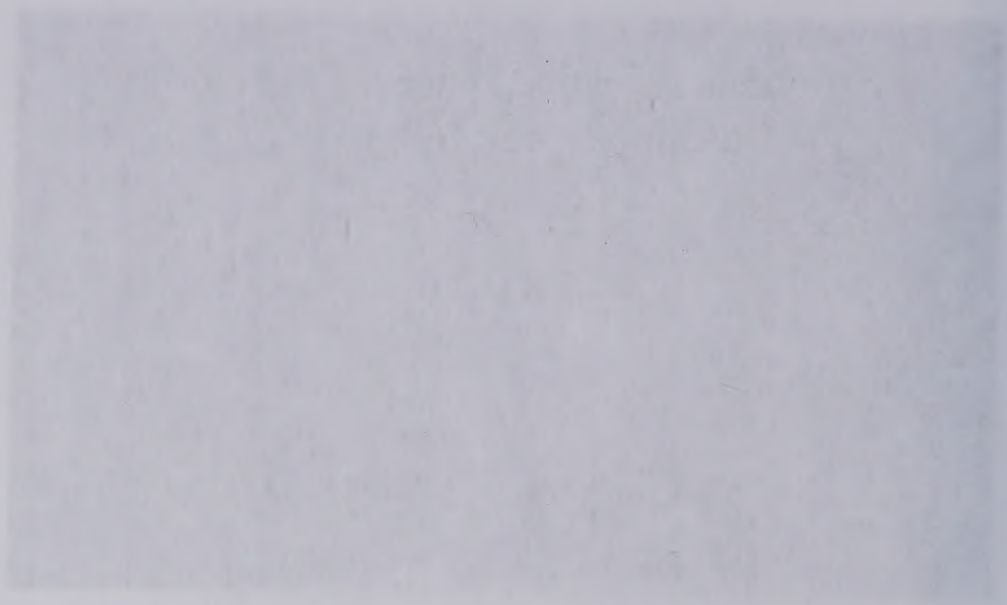

Abstract

The North Carolina swine industry has undergone unprecedented growth and restructuring during the last 25 years. The number of swine has increased, while the number of operations has decreased. The result is the industrialization of hog farms, and greater hog density in many areas. This increased density has resulted in increased risk from externalities caused by swine operations. Some of the possible externalities include water pollution, air pollution, water shortages, and reduction in property values for neighbors of swine operations. Due to these externalities, swine operations are unpleasant and according to some, dangerous to live around. The goal of this analysis was to use GIS and statistical analysis to determine if high minority, low education and low-income communities are disproportionately affected by these swine operations. This analysis was performed based on geographic equity, equal distribution across the area, and procedural equity (equal enforcement by the department of water quality). The geographic equity analysis was performed using three methods. The first method was a comparison of the percentage of land area with above state average values for socioeconomic variables (racial percentage, education and income), against the percentage of swine in that area. Inequities would be depicted when the difference between the percentages are large. The second method was a comparison of means for the socioeconomic variables between block groups with swine operations and those without. The final analysis was a logistic regression, regressing whether or not a block group had a swine operation against the socioeconomic variables. All of these analyses were performed for the entire state, and for the non-municipal areas. The procedural equity analysis was performed using county level data, regressing socioeconomic variables against percent of inspections and percent of violations. All of the geographic equity analyses showed results that would indicate inequities. For the entire state, in all of the analyses, at least education and racial percentages were indicators of industrial swine operations. For the non-municipal areas, race, income, and education variables all seemed to indicate locations of swine operations. Based on the variables, and the methods used in this analysis, it appears that there are environmental equity issues in the North Carolina swine industry.

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Problem Statement: Environmental justice emerged as a major issue in the environmental movement with the Warren County protest of dumping of PCB contaminated soils in 1982 (Bullard). Environmental justice is a movement to ensure that one group of people is not exposed to a higher level of environmental dangers based on their race or income. Since then, numerous studies have documented the discrepancies in distribution of environmental hazards, and enforcement actions for environmental hazards. These differences have been noted in various studies (Bullard, NLJ, Cable). Others have theorized that minority groups, are more at risk based solely on the color of their skin. This theory, known as environmental racism, states that African-American and other minority groups are exposed to higher levels of externalities, and do not receive the same level of enforcement of environmental laws.

A recent study found that minority communities are exposed to much greater environmental risks than white areas. This study states that fines for violation of federal environmental laws in minority areas are much lower than in white areas, in some cases as much as 500% lower. Additionally, Superfund clean up in minority areas is 20% slower, and can begin 12-42% later than in white areas. Further evidence of environmental racism in government action is the method of cleanup. In minority communities, EPA is more likely to cap off a hazardous waste site as opposed to treating it, while in a white area they are more likely to permanently treat the site (NLJ, Lavelle and Coyle). These studies show clear examples of one group of people being exposed to higher levels of pollution based on their race.

Other studies demonstrate the discrepancies between low-income minority areas and white areas to demonstrate the difference in environmental risks. A good example of this is lead poisoning in children. Previous studies have shown that in families earning less than $6000, 68% of African-American children had lead poisoning, compared to 36% of white children. When income is raised to $15,000, there is still a large discrepancy, 38% of African-American children had lead poisoning while only 12% of white children had it (Bullard). Another study showed that Latinos and African-Americans in Los Angeles are exposed to higher levels of air pollution. Additionally, 34% of whites live in heavily polluted areas compared to 50% of Latinos and 74% of African-Americans, showing some discrepancy in level of risk from exposure

between white and minority communities (Bullard). Based on these studies, there is evidence that minorities are exposed to a higher level of environmental danger than whites.

Environmental justice only recently became an issue in the hog farming industry. Until fairly recently, most hog farms were small, and the environmental dangers associated with them were minimal. This changed when the hog industry underwent a massive change in structure. The capacity of hog farms grew, and the number of hog farms decreased, resulting in fewer farms with a lot more hogs. North Carolina moved from eighteenth nationally to first in the production of food animals (Ladd & Edwards). This restructuring of the industry had drastic social and environmental impacts. While hog farming has grown and generates large amounts of revenue, it has become an industry. Many small family farmers have been driven out of hog farming by large corporations who can undercut their prices. Environmentally, the concentration of so many hogs in small areas resulted in many problems. These range from air and water pollution, to possible Pfisteria outbreaks. Obviously, people located around these facilities suffer greater risks, due to their proximity to the hazard. Concerned Citizens of Tillery (CCT) have argued that a disproportionate number of these swine operations are located in African-American communities. Due to the potential environmental risks associated with hog farms, it is unjust for one group of people to be exposed to increased levels of pollution based solely on their race.

Objective: The objective of this project is to analyze the location of swine facilities in North Carolina, to determine if any race or group of people is exposed to higher risks from the swine industry. This study will determine if there is distributional and procedural equity, in the North Carolina swine industry, both of which are symptoms of unequal protection (Diforio). For distributional equity, farms will be analyzed to see if they are distributed evenly across different groups of people. Additionally, this study will test to see if all groups of people are afforded the same procedural equity. Procedural equity means that laws are created and enforced equally for all races, and income levels. In order to do this, two main data sources will be used: 1990 North Carolina Census Data, and a Department of Water Quality Database that has relevant information on hog farms in North Carolina. This study will analyze this data using a

geographic information system (GIS) and statistical packages in order to determine if there is distributional equity. Distributional equity will be based not only on race, but additionally on income and education characteristics. To determine if there is some sort of procedural inequitablity, a multiple regression using a database compiled by the Southern Environmental Law Center, based on DWQ inspections, and county level census data will be performed. The goal of this analysis is to determine whether all groups of people are afforded the same level of protection in frequency of inspections, or in level of punishment.

Previous studies have concluded that environmental injustices and racism does exist. It is my goal to examine North Carolina hog farms to determine if any group of people is more exposed to a set of environmental hazards than another. This paper does not presume to make any conclusions about the nature of the injustice, whether it is deliberate or a product of market forces, but simply to determine whether it exists, and if it does, which factors are the strongest indicators.

Literature Review

Although there is an abundance of literature regarding the environmental justice movement in general, there is very little on the environmental justice of hog farms. Anthony Ladd and Bob Edwards provide information regarding the environmental justice movement in North Carolina. They focus on the swine industry in North Carolina, and the emergence of environmental justice in North Carolina. Additionally, they trace public attitudes about hog farms and the environmental impacts of these farms, analyzing the demographic composition of people who support and oppose the hog farms in North Carolina. They provide an overview of the emergence of environmental justice in the North Carolina swine industry, while also examining the growth of this industry.

A Masters' Project by Richard Diforio, a former student at the Nicholas School of the Environment, provides a framework for analysis for environmental equity. Diforio looks at a comparison of zip codes with and without hog farms and a temporal analysis to see if these characteristics change over time. This study provides evidence on a scale different to the one for this project that there does appear to

be inequities in the North Carolina swine industry. The Diforio article finds that there are some cases of inequitable distribution of hog farms, with lower income and higher minority population in those areas with hog farms. While the Diforio analysis focuses on zip code level, the focus of this paper will be census block groups, which are much smaller than zip codes.

Owen Furuseth also goes into an in-depth analysis of the growth of the North Carolina swine industry. He provides useful background on the issue, and analyzes what might have caused this growth. Furuseth also examines the restructuring of the swine industry, analyzing the emergence of contract farming, and the industrialization of hog farming. He argues possible reasons for the growth include favorable political support. This support may have allowed the industry to grow without some of the normal limits for an industry this size. This article provides evidence that hog farming has been encouraged by the state, resulting in a possible inequitable distribution.

Steve Wing and colleagues presented an analysis of environmental justice of swine operations in North Carolina. This article focuses on the causes of environmental racism, particularly in eastern North Carolina. This article examines the case of Tillery, North Carolina. Tillery is a good example of what community empowerment can do to help fight environmental injustices. This article not only provides useful background to the issue, and possible causes, but also provides an example of a community dealing with environmental justice issues, and how it is combating the inequities.

Separate studies by Douglas Lober and Theodore Glickman examine the use of GIS in siting facilities and testing for environmental justice. Lober examines how GIS can be used to more fairly site noxious facilities. He uses a "McHargian" site suitability technique, which is an overlay method, to determine which area might be most appropriate for a regional recycling center. Lober uses a GIS to examine two aspects of site suitability. First, he uses the distance from the facility to model public opposition to the facility. Next he used a land suitability method to determine which areas might be appropriate for such a facility. This analysis provides an interesting example of using GIS to site noxious

facilities. Lober does not take socioeconomic variables into account, but attempts to use GIS to find the best site for the facility.

Glickman examines the use of GIS to measure environmental equity. Glickman examines two methods of measuring environmental equity using GIS, proximity based measurements and risk based measures. A proximity-based measurement is based on the calculation of the number of people around the hazardous facility. A risk-based measurement is similar, but takes on more factors, such as the risk of a spill, or the size of the area that would be affected. Glickman provides a valuable framework for organization of GIS projects dealing with environmental equity. Glickman also examines the possible future of using GIS to test for environmental equity. He hypothesizes that with the availability of GIS software and toxic release data, that grass roots organizations will be able to test for environmental equity much more easily.

There are many other articles that address the larger topic of environmental justice. One prominent author in the field of environmental justice is Robert Bullard. His classic article "Anatomy of Environmental Racism", defines environmental racism, looking at various examples in federal policies. Additionally, it looks at a case study of environmental racism in California. Another article by Bullard and Beverly Wright examines environmental racism in siting of facilities, and regulation of these hazards. This paper also cites examples by looking at case studies from various Southern cities. These case studies provide valuable background to the issue, and show in some cases how grassroots organizations can be effective in overcoming environmental racism.

Marianne Lavelle and Marcia A. Coyle examine racism in environmental law enforcement. Lavelle and Coyle use data from the Environmental Law Journal to depict the inequitable distribution of protection based on race. Their data was collected over eight months, from 1177 Superfund sites, and there was clear evidence of environmental injustices. This study revealed that penalties under hazardous waste laws were much higher in minority communities than in white communities. This same study showed that the penalties were fairly even over income levels. Environmental penalties under clean air and water

programs were also much lower in minority communities. Superfund cleanup sites also took longer to cleanup in minority areas, and the EPA chose containment over treatment more often in minority communities. Although the EPA denies any deliberate differential enforcement, there is clearly a higher burden placed on minority communities. Although there is some discrepancy, it may not be deliberate; it is simply that these areas are frequently neglected. They also provide key background and facts, to support the theory that environmental racism does exist.

Another article by Bob Edwards examines the environmental justice movement, paying attention to the key groups in the emergence of the movement. Edwards examines how environmental justice emerged from the mainstream environmental movement. Although many of these articles seem to focus around the same theme, the emergence of the environmental justice movement, they each offer different perspectives, and observations. All of these can be put together so that an appropriate summary of the emergence of environmental justice can be written.

Other articles offer further insight to environmental justice, through further summaries and examples of environmental injustices. Cable and Shriver provide further evidence and background of environmental inequity in the United States and examine possible causes. Markham examines an issue for environmental inequity, but fails to find inequity. This article is useful because it mentions limitations in many environmental justice articles.

The other main section of background for this project focuses around the swine industry in North Carolina. One very valuable source examining the North Carolina swine industry was a News and Observer special report entitled "The Power of Pork". This section had a series of articles about the swine industry, examining the change in structure from many family farms to fewer factory farms. This section also looked at some of the dangers that can be associated with hog farms.

Bob Edwards and John Maiolo summarized survey data of people in Eastern North Carolina regarding their opinions of hog farms. Bob Wachs provides valuable information regarding public opinion

of hog farms in North Carolina, by addressing the swine industry issue from the local community's point of view. In order to establish that the location of North Carolina hog farms is an environmental justice issue, it is important to understand community reactions. Bob Edwards and Anthony Ladd summarized polling data, which addressed peoples' opinions of the swine industry in North Carolina. This article concludes that most people want stricter regulation on the swine industry.

Another area that information was needed for was the restructuring of the industry from family farms to factory farms. David Cecelski and Mary Kerr examine the switch from family farms to factory farms, and the effect that this switch is having on the area. This is an area of great debate, whether or not the industrialization of the swine industry has been good for the small farmer. This article provides good information regarding this subject. An article produced by the Missouri Rural Crisis Center traces the industrialization of the swine industry, and the fight of the people who tried to bring it back to family farms. Additionally, this article provides information about environmental hazards associated with industrial swine operations.

Another section to address in the background of hog farming was the dangers associated with hog farming, such as the Pfisteria outbreaks and fish kills that may be caused by hog waste spills. James Rosen examines this issue to some extent; he addresses the Pfisteria outbreaks and its effects, but provides little information about a causative link between this and swine waste runoff. Another danger of the North Carolina swine industry is psychological impacts of the odor from hog farms. Susan Schiffman and colleagues examine the effect of hog farms on the mood of local residents. According to this article, exposure to the odor associated with swine lagoons causes people to be in worse moods, and can result in nausea and other physical ailments. These articles give strong background material to the environmental externalities that are caused by the North Carolina swine industry.

One final area to address in the background section of this paper is procedural injustices in the legislatures' policy towards hog farms. One aspect of this is a two year moratorium on construction of new operations, passed by the legislature in 1997. This moratorium was part of the Clean Water Responsibility

and Environmentally Sound Policy Act, signed by the governor, April 28, 1997. James Shiffer and Kirsten Mitchell examine the huge growth of hogs immediately before and after the moratorium. This data is summed up in a Southern Environmental Law Center press release, discussing the growth of hog farming following the moratorium. Another area of legislation mismanagement is seen in articles such as one by Shiffer, which shows that North Carolina legislators are influenced by hog farms, due to their economic interest in them. This article examines the spill of waste on a farm owned by a North Carolina legislator. Another article by Mitchell discusses that, in some areas, hog farmers control hog farm inspections. Situations such as these offer some insight to the lax laws and enforcement of hog farm regulations. Although these newspaper articles are not as reliable as journal articles, they are much more current, and provide background information unavailable from journal articles.

Environmental Justice/Environmental Racism

Definition

Environmental Justice has many definitions depending on the source you use. It is logical that those who live in closer proximity to environmental hazards have a greater risk. The benefits of these hazards are divided among the entire population, most of whom are not directly affected by the environmental hazards (Edwards). Environmental justice serves as a means to relieve all communities, regardless of race or income level of the burden of environmental hazards (Diforio). Another definition says that all Americans despite race or income should be allowed equal protection under law (Bullard). Probably the most comprehensive definition states that environmental justice is, "the right to a safe, healthy, productive, and sustainable environment for all, where "environment" is considered in its totality to include the ecological (biological), physical (natural and built), social, political, aesthetic, and economic environments. Environmental justice refers to the conditions in which such a right can be freely exercised"(What is Environmental Justice? homepage). A common theme in all of these definitions is that one group of people should not be exposed to higher levels of environmental hazards based simply on the color of their skin, income or education levels. Neither the costs nor benefits of polluting activities are

evenly distributed. The environmental justice movement attempts to rectify these discrepancies.

Environmental racism is a similar concept. Environmental racism theorizes that people of color are exposed to a higher level of environmental hazards. Some feel that this environmental racism is a product of institutionalized racism. There are discrepancies in enforcement, siting and regulation (Bullard). Steps must be taken to alleviate institutionalized racism, if we are to eliminate environmental racism. Numerous studies have documented examples of environmental injustice and racism, which will be examined in this paper First it is important to understand the history of the movement, how it has developed, especially in North Carolina.

If there were no environmental justice or racism issues, then there would be environmental equity. Environmental equity can be defined as, "An ideal of equal treatment and protection for various racial, ethnic, and income groups under environmental statutes, regulations, and practices applied in a manner that yields no substantial differential impacts relative to the dominant group—and the conditions so created." (What is Environmental Justice? homepage). Environmental equity has three separate categories: procedural inequity, geographical inequity, and social inequity. *Procedural inequity* is defined as the extent that regulations and governing rules are applied evenly across all groups of people. This would include issues like fewer inspections for hog farms in minority areas. *Geographical inequity* is the inequitable distribution of costs and benefits for industrial pollution. All the benefits may go to an affluent community, while the costs are borne by a low-income community. *Social inequity* is the concept that, "Environmental decisions often mirror power arrangements of the larger society and reflect the still-existing racial bias in the United States." This theorizes that predominantly African-American communities are exposed to greater risks due to institutional racism, influencing siting noxious facilities in these areas (What is Environmental Justice? homepage). These categories of environmental equity can be used as a framework, to attempt to discern if environmental injustice exists in the areas of interest.

History of the Movement

The environmental justice movement emerged from the strong environmental movement that emerged in the 1960's. This predominantly middle-class movement built up a large political base. This strong movement, with its large political base, was able to stop hazardous waste facilities and environmental hazards. While the activists were able to ensure that the facilities were "not in my backyard (NIMBY)", these facilities had to be put somewhere. Urban and poor people seemed to be exposed to an unreasonable level of risk from environmental hazards. The recognition of this inequity spurned a new environmental movement, the environmental justice movement (Bullard).

While these environmental groups had a great deal of success in increasing regulations, they did little to endear themselves to minority and low income populations. These residents felt that the mainstream environmental movement did little for them, and that environmental quality was a luxury item. The environmental justice movement emerged from grassroots organizations, which were affiliated with the larger organizations. These grass roots groups are usually centered on single problems or issues, such as siting of noxious facilities.

This movement started in the South, where some of the most glaring injustices seem to take place. There has been an emergence of grassroots organizations, which try to alleviate some of the excess burden of environmental hazards on the African-American community. This as many other grass roots organizations was focused around the church (Lavelle & Coyle). There are so many environmental groups, that the focus of a group can influence the people who would join that group. Bullard proposes four issues that are likely to attract interests of black community leaders. These issues are those that advocate safeguards against environmental blackmail with strong pro-jobs stance, those that focus on inequality and civil rights, those that endorse the politics of direct action, and those that seek political empowerment of underdog groups. These types of groups are likely to be drawn to environmental equity issues. There have been numerous examples of environmental justice demonstrations. The first major protest occurred in Warren County, North Carolina (Bullard, Lavelle & Coyle).

This protest revolved around the selection of Warren County, North Carolina, in 1982, as a burial site for soils contaminated with highly toxic PCB's (polychlorinated biphenyl's). Instead of this highly toxic soil being properly disposed of, it was illegally dumped along rural roadways in North Carolina in 1978. This siting decision brought great protest from the local black community. Many protesters were jailed, due to protests and other direct actions against the facility. Unfortunately, these protests were ultimately unsuccessful in halting the facility, however, this was the first time that a broad base of African-American protesters got together to demonstrate against an environmental inequity (Bullard).

Case Studies

The Warren County incident was just the first of many protests that focused around equity issues. This section examines examples of environmental racism and injustices. These case studies emerge from various southern and Californian cities.

California

There are many examples of environmental injustices; there are also numerous examples of grassroots organizations interceding to block these injustices. According to Robert Bullard, California has many examples of environmental injustices. Bullard states that the zip code that South Central Los Angeles is in, is the dirtiest in the state. This zip code has 97% minority population. This neighborhood and neighborhoods in East Los Angeles were slated to be homes for hazardous waste incinerators. In the East Los Angeles community, a grass roots organization opposed this project. Eventually, they were able to draw enough attention to the issue to get regulatory agencies involved. When the regulatory agencies got involved, the company building found that the incinerator costs became prohibitive; thus the company dropped their plans to build in this community.

Houston

Another city that Bullard mentions as a case of environmental inequities is Houston, Texas. In the city, from roughly 1920 -1970, 75% off the hazardous waste facilities were sited in predominantly black communities. In 1979, residents rallied together to oppose Browning-Ferris Industries and their proposed garbage dump. The residents used multiple direct actions campaigns to attempt to draw attention to the polluting activity. They were unable to completely shut down the activity, but they were able to reduce the pollution. The city council passed ordinances to reduce the risk to local population. These ordinances included preventing city owned trucks from dumping at this facility, and regulated the distance that future landfills could be from public facilities. This protest also resulted in the Texas Department of Health requiring that socioeconomic data be included in waste disposal applications (Bullard & Wright).

Emelle, Alabama

Emelle is a rural community, with 626 residents, 90% of whom are African-American. This is also the site of the nations largest hazardous waste site, comprising nearly one fourth of the United States' hazardous waste facilities. Emelle is the site that holds wastes cleaned up from Superfund sites. Local residents were enraged by this facility moving into their community. Although this case is still ongoing, the government has levied fines against the toxic waste facility. Possibly more importantly, local African-American residents have joined forces with predominantly white mainstream environmental organizations. This will give much more political influence to a group that has not been historically very powerful in Alabama, low-income minorities (Bullard & Wright).

West Dallas

Dallas is a large well known city, what is not common knowledge is that eight out of every ten African-American residents live in predominantly African-American communities. West Dallas is a community that is predominantly African-American, with 85% of the population being African-American.

In this community, a lead smelting plant existed for 50 years that polluted the air, repeatedly receiving environmental citations, and poisoning the community. The community decided to attempt to close the plant and remove the contaminated soil. In this case, the polluting industry was shut down, and forced to pay a huge amount of civil damages to the local residents. Although they were able to shut down the activity, the site was not cleaned up, nor was the factory removed. Even in success, the grassroots organization does not accomplish all of its goals (Bullard & Wright).

These case studies show examples of environmental injustices, and possible solutions. They depict that there are numerous inequities, but there are also solutions. It seems that in many cases there is possible resolution. These resolutions are not ideal, in none of the cases mentioned above did the grass roots organization accomplish all of their goals. In order to draw attention to the inequities, these organizations frequently elicit media support, and direct action techniques. Through these methods, it is possible to attempt to alleviate some of the injustices. These cases also provide some evidence to show that environmental racism does exist. It is my goal to attempt to show that there are environmental justice and racism issues involved with the North Carolina swine industry. To understand this, we have to examine the environmental justice movement in North Carolina, and how it emerged around the swine industry.

Criticisms of Environmental Justice Research

Based on these case studies, it would appear that there is no doubt that environmental injustices are present in our society. There are, however, many people who feel that environmental justice is not as prevalent as it would appear from all this research. Some of these research methods are seen as flawed, due to a variety of factors, such as scale, and the number of variables included. It is possible for something to appear to be an environmental justice issue on one scale, such as the county level, and not be an issue on a smaller scale. For example, when looking at county data, it may appear that counties with high minority population are in those areas with Superfund sites, but when this is examined on a smaller scale, such as census blocks, then there seems to be a more equitable distribution. Studies have even found that in some cases, more affluent communities are more likely to get locally unwanted land uses (LULU's) than poorer

areas (Markham). In order to try to alleviate environmental justice phenomena that will disappear at smaller levels, this paper hopes to look at the smallest census unit that are appropriate, census block groups. If the smallest unit is examined over a large area, then it can be established if an injustice is an isolated phenomenon, or if it occurs the same way over the entire state.

Another criticism of environmental justice studies, is the choice of variables. If one variable such as percentage of a race is chosen, and the research is done just for that variable, then the conclusions can be skewed. It is more appropriate to include numerous variables for education, income and race, to see if any of these variables are an indicator for LULU's. Obviously, it would be impossible to include every variable that could be included in the rationale behind locating swine operations, but it is important to recognize the limitations of the analyses that are performed. Many studies fail to do this, instead choosing to treat the variables chosen as the only ones that could have an effect.

Finally, many studies fail to look at cause or try to assign blame. Some studies seem to find a case where minority groups are exposed to higher environmental externalities, and assume that this is intentional racism. In actuality, it could be due to a number of other factors, such as coming to the hazard, where low-income communities emerge around hazardous facilities due to cheaper land costs, or market forces dictating the siting. It is important to remember that if there is environmental injustice, it is not always intentional discrimination, and it is very difficult to establish this link. Also, the cause is often not understood. Landfills may occur in the inner city, but this may also be because this is the area that produces the garbage, so it is cheapest to dump it in that location.

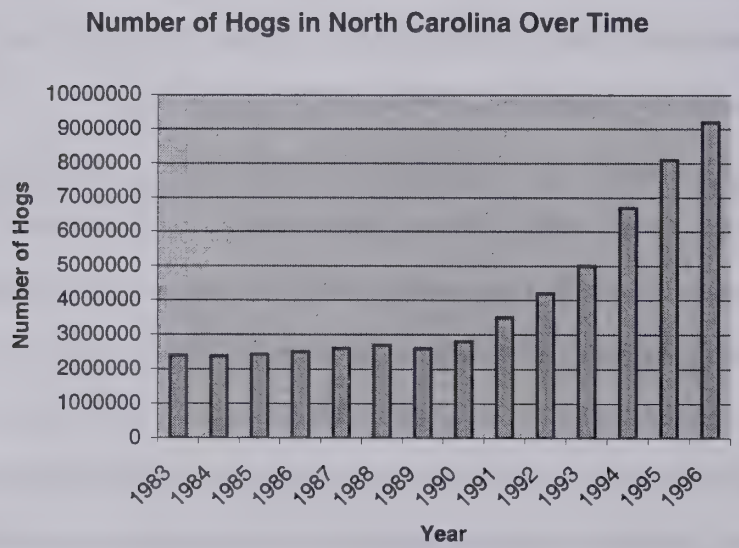
These criticisms are important to understand when looking for cases of environmental injustices. Although the case studies mentioned above indicate numerous examples of environmental injustice, this data could be skewed. This paper does not argue that environmental injustices do not exist, clearly from the work of researchers such as Robert Bullard, they do. It is important, however, to understand the limitations of the research and to make those clear to the reader, so that they can understand the limitations, and also the strengths of any analysis that has been performed.

North Carolina Swine Industry

Growth and Restructuring of the Industry

Recently, the North Carolina swine industry has experienced massive growth. Over the last ten years, the number of hogs has grown from around 3 million to 10 million hogs (Ladd & Edwards). This growth is shown in figure 1. This means that North Carolina has become the second largest hog producing and the fastest growing hog producing state in the country (Diforio, Ladd &Edwards). North Carolina is now the number 1 animal producing state in the country, up from 18th 25 years ago (Animal Agricultural Waste Task Force, Ladd &Edwards). Currently, North Carolina produces about 11% of the nation's pork (Ladd &Edwards). Hog production was able to grow at such a rate, due to increases in technology, in areas such as confinement and more efficient feeding. Now, it is possible to raise thousands of swine on a very small area (McKee & Hall).

Figure 1

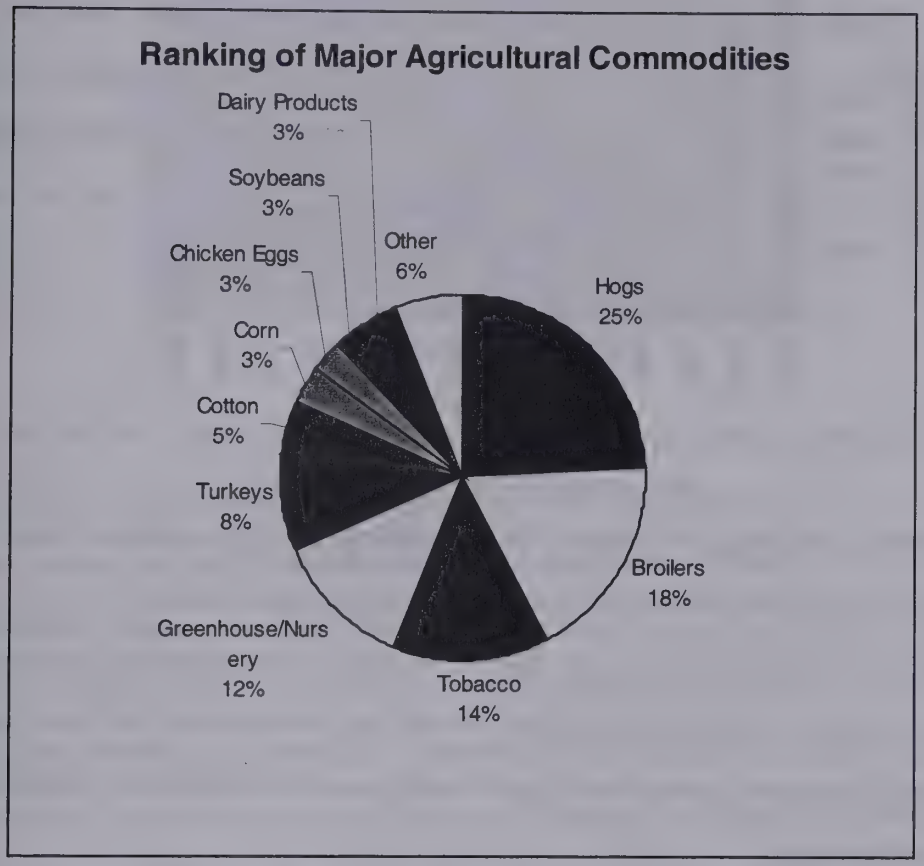


Source: North Carolina Department of Agriculture

Along with this rise in the number of hogs, there has been an increase in the number of jobs associated with this industry. Directly, the swine industry employs about 7200 people, and indirectly, 23,000 people are employed in other sectors related to the industry (Ladd & Edwards, Diforio). Swine is

now the state's largest agricultural commodity, and many people rely on hog farming for a source of income. Figure 2 shows the ranking of swine production as the percentage of North Carolina agricultural revenue. Clearly, swine operations are a very important producer of agricultural revenue.

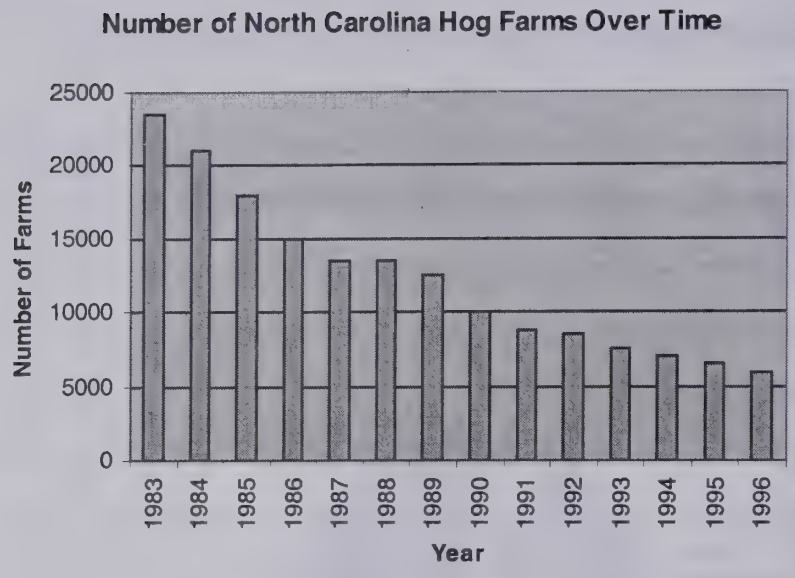
Figure 2



Source: North Carolina Department of Agriculture

The swine industry has not only grown, but it has also undergone a major restructuring. As the number of hogs has increased, the number of swine operations has actually dropped. The swine industry has undergone an industrialization, becoming a multi-million dollar industry (Ladd & Edwards). In 1989, the average number of hogs per farm was 206, in 1995, that number was 1258, and the number of farms was 7000 in 1996, as opposed to 24,000 that existed in 1984 (Ladd & Edwards). Clearly, there has been a dramatic change in the size and structure of North Carolina swine operations. Figure 3 offers a graphical depiction of this change. Concentrated animal feeding operations (CAFO) have become more common as hog farming became more of an industry.

Figure 3



Source: North Carolina Department of Agriculture

In addition to this change in scale of hog farms, the structure of hog farms has also changed. The farrow to finish hog farms that raise swine from birth to slaughter, have been replaced by many different farms. In the industrial swine process, one farm may birth the piglets and raise them until they are weaned, when they will be sold to a farm where they will be raised until they are slaughtered. The latter is known as a finishing farm. This system optimizes labor to capital return, through specialization, and reduces the risk of disease (McKee & Hall).

Reasons for Growth

This massive growth in the North Carolina swine industry did not occur by chance, this was a carefully planned growth, for swine production to pick up for drops in production of tobacco in the North Carolina economy (Swine Odor Task Force). This growth was heavily subsidized through grants and tax incentives to hog farmers. These incentives include sales tax exemption from equipment and buildings, and numerous other tax-free activities (Furuseth). This growth in the industry has also been helped by the fact that many of the legislators in North Carolina have close ties with the swine industry. Wendell Murphy

owns the largest swine operation in the United States, and during his time as a North Carolina legislator, was crucial in establishing many of the laws that have allowed the swine industry to grow so large. This legislation included reductions in the state's ability to penalize for illegal discharges (this has been partially restored), and measures to keep counties from using zoning to deal with odor from swine operations (Warrick and Stith). These operations are treated as family farms, regardless of their size and are given exemptions to zoning ordinances, not afforded to other industries. Hog farms are even exempted from legal complaints generated by neighbors. These lax regulations and strong incentives have resulted in the emergence of eastern North Carolina as one of the largest hog producing regions in the entire country.

Contract Farming

Another aspect of this restructuring is what is known as contract farming. In many cases, the large industrial farmer has made it difficult for the small independent farmer to compete. The industrial swine operation can lower costs, and undercut the smaller independent farmer. This has driven many of the small farmers out of the business, as is evident when looking at the reduction in number of swine operations over the last 10 years. Many small farmers trying to stay in business have turned to contract farming. Contract farming is a process where a large industrial hog operation gives a farmer a contract to raise a certain number of swine. The price for these swine is fixed, and the industrial operation will buy them when they are ready for slaughter, or the next step in the integration. There has been a lot of debate about whether this process is good or not. Clearly, the farmer is less susceptible to market dynamics, which has both its good and bad sides. If the pork market fails, he won't be financially ruined, but if the market explodes, he does not reap the benefits. Critics of this process have argued that it places the burden of environmental responsibility on the farmers, while the industrial swine complex reaps the benefits. If a lagoon fails on a contract farm, it is the farmer's fault, and he is responsible for any penalties for that.

Another criticism is that it can skew perception of the industry. Contract farming makes the industry look like a group of family farmers, most people do not realize that all the pigs grown on the family farms are actually for industrial swine operations. Whether these contract farms are actually a good or bad

idea for the farmers remains to be seen, but the most important aspect of them is that they allowed many farmers to stay in business who otherwise would have been forced out. Some farmers like the security of contract farming. Contract growing is seen as an alternative to the economically uncertain life of an independent farmer. If not for the farmer's acceptance, contract farming would not have grown so large (Furuseth).

These changes have not come without problems, environmental problems such as water pollution and air pollution have made life unpleasant for neighbors. With the emergence of CAFOs, the concern over environmental dangers associated with swine operations became greater. In the past, hog farms were so small, that the environmental effects were largely ignored, but with swine operations getting larger and concentrating in smaller areas, the neighbors of these operations became more concerned.

Environmental Externalities

Numerous environmental externalities have been associated with swine operations, and the swine waste produced by these operations. Hogs typically produce eleven pounds of waste daily (McKee & Hall). Farms have no obligation to treat this waste, and in most cases it goes untreated. Current technology has waste flow from the production facility, into a ditch that leads to a large holding pond or lagoon. Theoretically, this lagoon holds the waste, with the solid waste settling to the bottom of the lagoon to work as a liner. From this lagoon, this waste is sprayed onto agricultural fields. This system works well in theory, but recent history shows this system is fallible.

This system can fail in a number of places. First of all, the lagoon can overflow. In recent years, this occurred numerous times, due to heavy rains or flooding. Another danger is that the lagoon walls will break, resulting in a spill. Another danger is that unlined lagoons can leak into the ground water. Lined lagoons are much more common now, but many unlined lagoons still exist and are a danger to groundwater. Another possible failing of this system is spray application of waste to fields. While this waste is a good fertilizer, if it is over-applied, then it can runoff the land and into water bodies. Another place this system

can fail is that the ditch from the operation to the lagoon can become blocked resulting in leaks. These leaks are very dangerous and can result in numerous environmental externalities.

- *Air Pollution*

  The vapors that are emitted from swine waste are a mixture of gases such as ammonia, hydrogen sulfide, and methane (Hog Wars). In a study in Minnesota, in a 32 lagoon sample, 25% of the farms failed air quality standards for hydrogen sulfide. These fumes have been known to cause headaches, blackout periods and vomiting. One study conducted by Family Farms for the Future found that greater than 50% of people living within two miles of mega-hog sites experienced greater incidence of allergies, sinus infections, and an overall lack of energy. Animal agriculture produces 1.5 billion tons of waste yearly, this is enough to cover the 1.9 billion acres in the continuous forty-eight states. This waste has high levels of volatile organic compounds, such as ammonia and hydrochloric acid. In a recent study, persons living near a swine operation were found to experience higher levels of tension, depression, fatigue, anger, confusion and had less vigor (Schiffman et al). The reason for these effects could be physical or psychological, but the main conclusion is that proximity to a swine operation causes a decline in the quality of life of the people who live nearby.

- *Water Pollution*

  Hog waste contains large amounts of heavy metals. These contaminants are the major source of pollution to the water from the waste. As mentioned above, different failures in the swine waste handling process can result in water pollution. This pollution can either be groundwater pollution, which is common in the eastern part of the state due to shallow water tables, and leaking lagoons, or surface water pollution, from the runoff, or lagoon flood or break. Groundwater pollution is especially dangerous in rural areas where people have wells. If hog waste pollutes the water source, then the people have no economical way to get water. Surface water pollution is dangerous for two reasons. First of all, it is a source of drinking water, but it is also a source of income and

recreation. When hog waste leaks into rivers, it can cause fish kills, this is devastating for people who rely on fishing for their income. This also disrupts the entire ecosystem disrupting animal's reproductive habits (Hog Wars). Additionally, North Carolina has a large tourism industry, especially in the coastal areas. If waste spills pollute the coastal waters, then tourism and recreation can be damaged. Also, hog waste produces ammonia, which escapes from these open air lagoons, and returns to the earth as rain. This ammonia is believed to be responsible for the production of algae that is choking off rivers (Satchell).

- *Water Loss*

  Not only do these operations pollute water, but they also use great quantities of it. An 80,000 head finishing plant in Missouri uses 200,000 gallons of water daily, this equals 73 million gallons a year. Slaughtering facilities for that plant use 365 million gallons per year. This is a total of 438 million gallons of water per year. Added across for all swine operations, this number is staggering. This use of water has led to the drying up of multiple wells in the region (Hog Wars). These operations clearly can lead to serious environmental problems.

In addition to these environmental externalities, and reduced quality of life, there is now evidence that swine operations actually lower the property value around them. Homes in areas with swine operations were actually worth less than those away from hog farms. In a North Carolina study, an area with 60,000 hogs, had a median house price of $60,234, while a comparable house without the swine would be $65,284. Also, those areas that had swine operations move in where there were none before seemed to have the greatest impact on the price of homes (Warrick). In a separate study, in North Carolina, it was found that a new swine operation lowered the price of a house significantly. As the location of identical houses change from an area with few swine to an area with many swine, the value of the house drops by more than $6000 (Palmquist et al). These studies provide evidence that swine operations can actually lower home values for those in close proximity.

Emergence as Environmental Justice Issue

As the hog farms grew from family farms to industrial operations in scale, people surrounding this industry began to become concerned with the externalities. Not only were the farms larger, but they were more concentrated. Around 95% of hog farms are concentrated east of Interstate 95 in North Carolina (Ladd & Edwards). This concentration could be due to better conditions for hog farming, such as topography and existing infrastructure, or it could be due to the cost of land. People also realized that hog farms were affecting certain groups more than others. Traditionally, industries tend to locate around rural areas with large African-American populations, due to the low cost of labor and land, and the lack of organized opposition. North Carolina was first exposed to the issue of environmental justice with the Warren County protests, so the people were already somewhat organized against industrial polluters. Not only are these industrial swine operations polluting predominantly African-American communities, but they are also putting small African-American farmers out of business. In Halifax County, in eastern North Carolina, these industrial operations moved in, bringing their packinghouses, and related industries, driving many local farmers out of business. These industrial operations brought many of the environmental externalities mentioned above to the area. With the size of these operations, came an increase in the risk of exposure to the environmental externalities. In some areas, grass roots organizations have grown up to oppose this industry. One of these groups, Concerned Citizens of Tillery (CCT) is located in Halifax County. This organization has documented some of the cases for environmental justice in North Carolina. According to their findings, the hog farms are located in areas that are predominantly African-American or high in poverty rates (Wing et al). Evidence indicates that there are environmental externalities associated with the swine industry in North Carolina. According to CCT, these externalities are felt to a greater extent by poor people and African-Americans.

Public Opinion

A large swine operation of 10000 pigs produces as much waste as a city, without any kind of treatment plant, so clearly people have strong opinions about living next to them (Cecelski). With very

little legislative regulations and relatively small fines, life near a hog farm can be very unpleasant. Not all people feel that industrial hog farms should not locate in their communities. Public opinion about hog farming seems to vary widely. Many newspaper articles seem to indicate that many people do not want these swine operations (Shiffer 97 & 98, Wachs). While the majority of the literature seems to indicate that most people oppose industrial hog farms in their neighborhood, some people may favor these industrial hog farms, because of the jobs they provide. If the industry brings jobs to an area, frequently the environmental effects are overlooked. Others fear these industrial operations, because they may drive the family farmer out of business (Cecelski, Wachs), while others see it as a chance to remain in business as a contract farmer. This makes the swine industry issue very complex, because while it pollutes, it also provides revenue for many local citizens. Although jobs are created, the positive economic benefits are small in comparison to the costs of the negative externalities. The overall opinion according to many is that people do not want hog farms in their communities. A 1995 public opinion survey, conducted in Eastern North Carolina, revealed that 86% of the people surveyed felt that stricter hog farm regulation would have a positive impact on their quality of life. 85% felt that pollution of rivers and sounds, and 73% felt that hog farms had a negative impact on their quality of life. Additionally, people felt that more hog farms were the second worst environmental trend, behind increasing pollution of the sounds and rivers. As mentioned above, swine operations can be linked to water pollution, so it is clear that people see swine operations as a threat to quality of life (Edwards & Maiolo).

The information presented above shows that in many cases the swine industry does not make a good neighbor. The swine industry is, however, a huge source of revenue for North Carolina, and the only source of income for many small farmers. Alternative, more sustainable agricultural methods should be found to replace this industry, but this must be done at rate that will not drive the producers into bankruptcy. Now that the dangers to the swine industry have been examined, it is obvious why an inequitable distribution of this industry in African-American and low income communities must be recognized, if it exists, and changed as soon as possible.

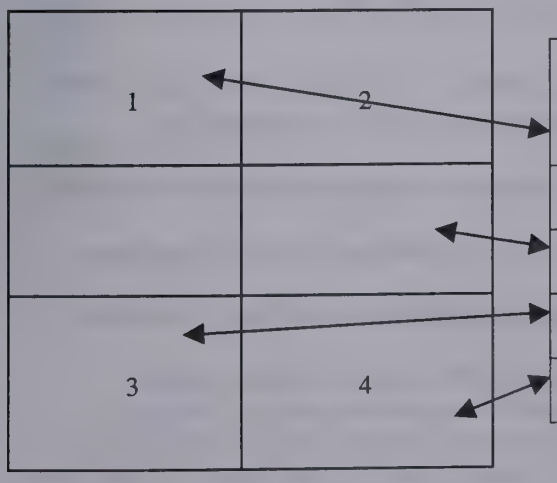
Geographic Information Systems

What is a Geographic Information System?

The goal of this paper is to use a geographic information system (GIS) as a tool to detect environmental inequities in the North Carolina swine industry. Before doing this it is important to understand exactly what a GIS is and what its capabilities are. By the strict definition, a GIS is, "An organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information" (ESRI pg. 1-2). More simply, it is a computer system designed to analyze information based on location. The program used for this study is ARC/INFO. ARC/INFO has two components. One component is the actual arcs, points and polygons, that make the shapes, composing the maps and images that are created using a GIS. The other component is an information database, which contains all of the attributes that describe these shapes. These two types of data are linked together so that one can query the data spatially.

For an example of a GIS, consider figure 4 below. Each one of these rectangles can contain data, so if this was a data layer of counties and the desired product was a map showing all counties with 500 or more industrial swine operations, with a GIS, this is a straight forward process.

Figure 4 Example of GIS Relational Database



County #	Latitude	Longitude	# of Swine Operations
1	35N	76E	5000
2	33N	77E	100
3	35N	77E	500
4	34N	76E	400

Each polygon is matched to the information table, so that one can select geographic features by their attributes. In the example above, polygons one and three could be shaded one color to show that they are the areas of interest. This is a very simple example, but it shows how the spatial data and information table are linked and can be used together. This can be used for much more complex analysis, with multiple data layers.

These data layers, also called *coverages*, can include many different data columns or *attributes*. Some of the data layers used for this project had over 100 attributes. More complex analyses include querying multiple data layers. For example, if the goal of a project was to use GIS to site a hazardous waste facility, you would need a list of requirements for the land use. This might require a specific type of soil, or a minimum distance from certain facilities, while also requiring a certain maximum cost requirement. As long as all of these data layers are available, then this analysis can be performed by simply querying these multiple data layers at once, to find the geographic area that satisfies all of these requirements. The GIS analysis required for this project is of a simpler nature. Most of the analysis requires simple *overlays*, which is laying one coverage on top of another, for the purpose of analysis. For example, one of the goals is to determine the percentage of swine operations that occur in predominantly African-American communities. This analysis would require a selection of all of those polygons with percentage African-American residents greater than 50%, and then an overlay of this with the coverage of swine operations, to determine how many of these features lie in a common area.

Using these methods, GIS is a useful tool for detecting environmental equity issues. The geographic aspect makes the analysis easier to understand, because it provides mapped evidence, instead of raw numbers. Multiple coverages can be put together to form *views,* which can be used to create maps. Also, ARC/INFO is easy to use with other programs. For example, after the data has been queried in a GIS, it can easily be placed into other programs, such as SAS/Insight, which is a powerful statistical package. These maps, along with the data analysis capability of GIS, constitute a powerful tool for examining environmental equity issues.

Methods

Creation of Data Sources

Swine Operation Coverage

In order to analyze the data in an appropriate manner, several preprocessing steps were required. For the hog farm data layer, the data set containing simple latitude longitude coordinates had to be converted into a geographic coverage that could be used in relation with other coverages. Initially, the data set had to be queried manually, and the hog farms that did not have geographic coordinates associated with them were deleted. These operations could not be used in the analysis, because there was no way to spatially reference these points. The original database containing the location and information about the farms, including size and type, was reduced to a table with just location and identification number. From this set, the generate command in ARC/INFO was used; this generated a coverage with those coordinates. At this point, the rest of the information was reattached to the coverage based on the common attribute of identification number. In order to make sure that these locations were correct, this coverage was overlaid with the state boundary for North Carolina, and all of those farms that were outside the state boundaries were identified. These were removed, because the coordinates must have been entered incorrectly. Out of the original 2966 industrial swine operations, 2666 were in the output GIS coverage. The final step was to use an Excel database, to reattach the information from the database back to the coverage, such as size and farm name. The final result was a coverage, with hog farms located by their latitude and longitude coordinates, this can be seen in map A2, which shows the location of all industrial swine operations in North Carolina.

Census Data Manipulation

The 1990 census data coverage contains social and economic information, on the block group level, for all of North Carolina. Map A-1 shows the census block group boundaries for North Carolina. In

order to examine for environmental equity, socioeconomic determinants of equity had to be determined. Similar to Lober's study based on using a GIS for siting a regional recycling center, the measure of environmental equity was based on three major factors: education, income and racial composition of block groups. A block group is a division that the Census Bureau uses for tabulating statistics. In order to look at these statistics, some manipulation of the data was required. The advantage of a GIS based system is that these kinds of manipulations are relatively easy, considering the size of the data set. This allows for in depth analysis in a short time.

In order to look at racial composition, a new attribute based on racial percentages was created. The coverage had raw numbers for racial characteristics by block group, so an item based on racial percentage was added. The percentage of African-Americans for each block group was calculated by dividing by the total population of that block group. This step was repeated for the white population. This resulted in attributes for percentage white and percentage African-American in each block group.

The next census characteristic examined was education levels. The census data had information on all levels of education, from number of people who have less than a ninth grade education to those people that have received graduate degrees. These raw numbers also had to be converted to percentages for the analysis. In order to do this, the number of people in a specific group for example, those with less than a ninth grade education, was divided by the total number of people in all classes. The reason for dividing by the total number of people with any education, instead of the entire sample is that the census does not count everyone in the census when considering education, due to age limitations. It would not make sense to calculate people under 18 as not receiving their high school diploma. The final attributes added to the coverage were percent education less than ninth grade, percent of people who have some high school education, but did not graduate, percent high school graduates, percent with Associate's degrees, percent of people who have a Bachelors' degree and percent with a graduate degree.

The final characteristic of the census data of interest was the economic criteria. Specifically, the environmental equity analysis was to be run on percent of people in poverty and percent of people who

make below the median income. In order to test for these characteristics, new attributes had to be added to the database in the same manner as described above. In order to test for percent of people in poverty, a poverty level had to be established. This was established by looking at the state census data, which had information on income levels that are classified as poverty, the family poverty level for 1990 was less than $12,500. After establishing what level of income could be classed as poverty, the next step was to determine how many people fell into that category. Income distributions in the census data are divided up by ranges. For example, for a particular block group, 10 families may make below $5000. Fifteen families may make between $7500 and $5000, and the ranges go up to over $100,000. Based on the established poverty level, the number of people who make below that can be determined by adding the ranges together. The sum of those ranges can then be divided by the total number of families that work. The output of this calculation is the percentage of families in poverty. Similarly, by adding all the ranges below the median income level of $30,000, and then dividing by the total number of people who work, one can establish the percent of people who make below the state median income.

These manipulations of the original database created ten new attributes. They are: percent African-American, percent white, percent below the state poverty level, percent below state median income, and the six education categories mentioned previously. Based on this manipulation of the census data, various analyses for environmental equity issues can be performed.

Creation of Inspection Database

In addition to the analysis based on environmental equity of hog farm sites, an analysis of equity of enforcement was performed. This analysis was performed on a much broader scale. The Southern Environmental Law Center maintains a database, showing the number of hog farms per county, number of hog farm violations, and number of water quality violations, obtained from the Department of Water Quality. Based on this information, an analysis of these variables against education levels, income data, and racial characteristics of the counties was performed. In order to do this analysis, a database had to be created.

This database contained socioeconomic information on the county level. This information was obtained from the 1990 census. This database is similar to the previously discussed block level database. Each county has a column for people with less than ninth grade education, people with some high school, high school graduates, people with a Bachelors' degree, and total number of people with any education. Percentages were also computed for each of these characteristics. Additionally, there are columns for percentage African-American and percentage white. The final socioeconomic characteristic is percent poverty and average median income for each county. The other columns in this database are number of hog farms, percent of hog farms inspected, percent of violations, and percent of water quality violations. A water quality violation is defined as any violation that may have an adverse impact on the water quality of the state, while any other problem with the farm is considered a violation.

Methods of Analysis

Percent Area vs. Percent Pigs

In order to examine the relative amounts of hog farms based on the criteria set forth, I initially examined areas based on state average for various criteria. Using census data, I established state averages for all of the criteria of interest. They are shown in table 1.

Table 1 Socioeconomic Averages for North Carolina

Less than ninth grade education	12.7%	Percent African-American	22.0%
Some High School, but not Graduated	17.3%	Percent White	75.6%
High School Graduate	29.0%	Percent Below Poverty	13.0%
Bachelors' Degree	12.0%	Median Income	$29,854

Based on these averages, the GIS was used to select all of those areas that had higher percent African-American, lower percent white, lower education and income levels. After selecting just these block groups and subsetting them from the overall coverage, this coverage was used to determine the total number of hogs in those areas. The method for doing this was using the ARC/INFO clip command, this works to clip

out all the features of a coverage that lie within a specified boundary. In this case the boundary was the coverage of the selected areas. This step was repeated for all the criteria of interest. Once the overall pig coverage had been clipped with each criterion, the goal was to examine the percent of area that one of these criteria occupied, against the percent of pigs. This method does not prove anything statistically, because all of the criteria could be correlated, but it does depict possible environmental equity issues in an interesting way. In order to determine the area each coverage occupied, the statistics command was performed on the area attribute, in ArcEdit. This sums all of the areas for each block group. The area for the entire state was also calculated. Based on these numbers, it was possible to establish a percent of land area that each criterion occupied. The next step was to examine the number of pigs in each subset. The percent of pigs was calculated for each criteria also. This step was repeated after removing all of the municipal areas from the data set. The reason for this is that most hog farms will not be found within municipal boundaries. Thus, all of the census blocks that were predominantly within a municipal boundary were removed. The result is a set of graphs that show the percent of pigs and the percent of area, and where there is the largest divergence. This visually identifies areas of possible inequity. Again, this method does not prove environmental inequity, because it does not account for cross correlation between variables. In order to test statistically, if there is a case for environmental racism or injustices, multiple statistical analysis will be performed.

Comparison of Census Divisions with Swine Operations vs. Those Without

Another preliminary analysis was to compare the socioeconomic criteria of census divisions with hog farms to those that do not have hog farms. In order to do this an overlay of the hog farm coverage, and the census data coverage was performed. In ArcEdit, all of the census blocks that had hog farms were selected; a value of one was assigned to these hog farms. Next, this selection was inverted to assign a value to all those census groups without hog farms. The same process was done on the coverage that had all of the municipal boundaries selected out of it. The ArcEdit statistics command was used with these coverages

to determine the means of the socioeconomic criteria of interest. These were calculated for the entire state, statewide census blocks with hogs, statewide census blocks without hogs, subset without municipal boundaries, subset with hog farms, and the subset without hog farms. These data could be used to determine whether areas with hog farms appear to have lower education, income and higher racial percentages.

Statistical Analysis

In order to analyze the statistical data, the categorical variable of whether or not the block group had a swine operation was used. This attribute classified each census division as either having a hog farm or not having one. This attribute allows for a binomial logistic regression. This type of analysis is used for regression when the dependent variable takes on one of two possible values. In this case, either a census group has a hog farm or it does not. Is it more likely that a hog farm is in an African-American or poor community? A logistic regression is used for analysis of the relationship of variables to a categorical variable. The results can be used to predict whether or not a census block group is more likely to have a industrial swine operation based on these variables.

To analyze the inspection database, a multiple regression was used to explore correlation between the socioeconomic variables and the number of inspections. Similar regressions were estimated for percent of violations and percent of water quality violations. Before these regressions were run, a correlation matrix was created depicting the correlation between each of the socioeconomic variables in order to test for multicollinearity.

Results

Percent Area vs. Percent Swine Operations

Entire State

The initial analysis performed on the data was to compare the percent of land in each of the categories previously mentioned and the total number of swine operations in that class. There is an addition to the original variables, areas with less than 5% African-American population. If there are environmental inequities, then large discrepancies can be expected between the percent of land area in the entire state, and the percent of swine operations. If there is true equity, then the percentages would be approximately equal. The results from this analysis are shown in table 2.

Table 2: Percent of Land Area vs. Percent of Swine Operations for North Carolina

	Percent of Land Area	Percent of Swine Operations
Majority African-American	12.91%	19.72%
Greater than 22% African-American	36.63%	58.18%
Less than 5% African-American	37.80%	8.93%
Less than 75.6%White	39.20%	66.32%
Above State Average Education Less than Ninth Grade	61.38%	86.80%
Above State Average Some High School No Diploma	69.96%	98.87%
Above State Average High School Graduates	26.18%	19.20%
Below State Average BS/BA	89.20%	99.85%
Greater than 25% of Families Below Poverty Level (<$12,500)	52.89%	82.52%
Greater than 65% of Families Making Below Average State Income (<$30,000)	42.91%	67.52%

Clearly, there are large discrepancies between the amount of land in each of these categories, and the percent of swine operations. For all of the racial categories, with the exception of majority African-American communities, there is a difference greater than 20%. For greater than 22% African-American and

less than 75.6% white, roughly 35-40% of the land area is in these categories, and there are around 60% of the industrial swine operations in this same region. Map A-4 shows the concentration of swine operation in block groups with above state average African-American population. This large discrepancy indicates that there may be a tendency for industrial swine operations to be located in areas that have larger percentage of African-American populations or lower percentages of white populations. This is supported by the fact that those areas that have less than 5% African-American population occupy 37% of the land area, but only 9% of the industrial swine operations. This indicates that these swine operations are more often located in communities with higher levels of African-American populations, and communities with lower percentages of African-American populations seem to be more often spared from the dangers of exposure to this industry, as shown in map A-5. The economic characteristics also seem to indicate that swine operations are located in areas with high levels of poverty, as shown in map A-6, and areas where many families are below the median income. The education characteristics also have high discrepancies between the percentages for above state average for less than ninth grade education and above state average for some high school but no diploma. Map A-7 shows the concentration of industrial swine operations in areas with above state average levels of low education. The other results are all a difference of around 10, which still appears to be high, but not as strong of an indicator as the other variables.

In order to get a more clear understanding of this phenomenon figures 5 and 6 were created. Figure 5 depicts the percent land area vs. percent of swine operation, those characteristics that display the largest discrepancy are those that would indicate an environmental equity issue. In order to display this, figure 5 was created to show those two percentages against one another. To clarify this relationship, another graph was created that displays the actual difference between the variables (figure 6). This graph depicts the differences between the percent land and the percent swine operations for each of these variables. This graph shows the expected results, positive differences for all but less than 5% African-American and those with above state average of high school graduates, which would be expected to have less area than swine operations if there was environmental equity issues.

Figure 5

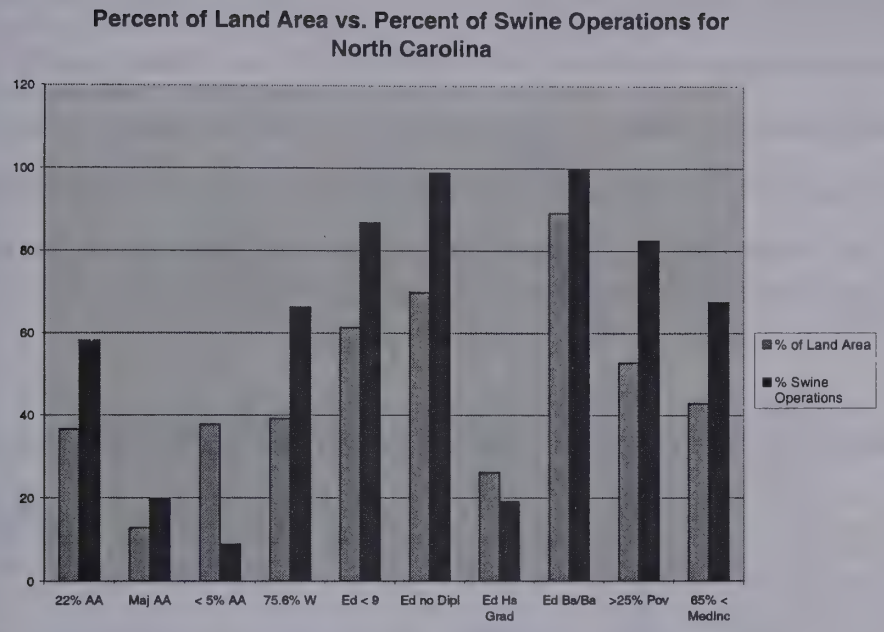
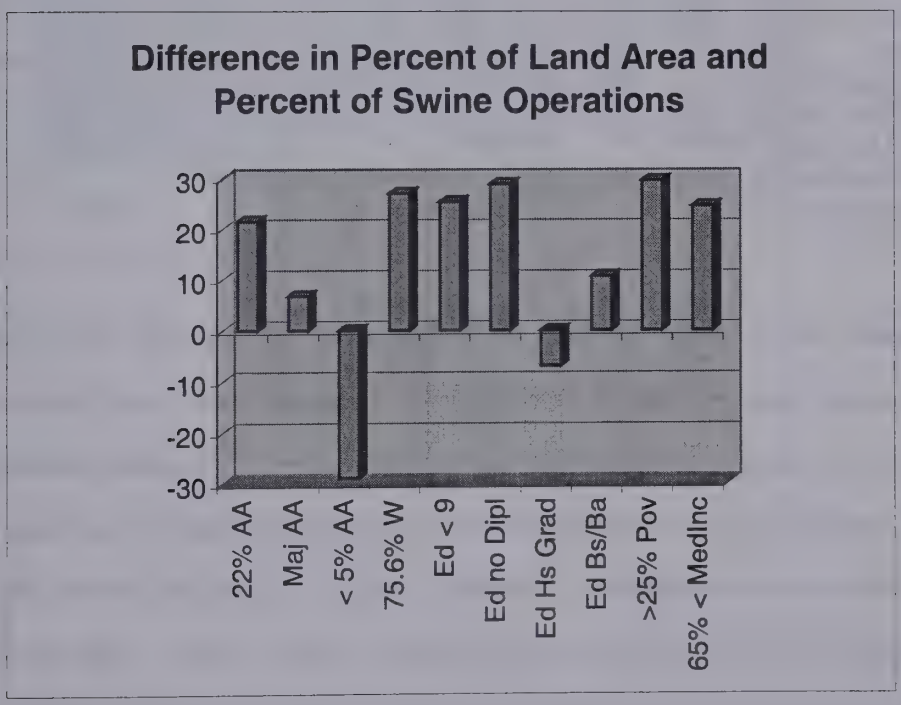


Figure 6



Rural Data

One of the criticisms of a project of this scale is that it does not take into account the fact that these swine operations could not be located in an urban area. To account for this fact, all those census block groups that fall within municipal boundaries were selected and deleted. The municipal areas are shown in map A-3. These block groups were deleted, so that only the non-municipal areas are left. The resulting data set was made up of non-municipal areas. The analysis above was repeated with this data set. The results are displayed in table 3.

Table 3: Percent Land Area vs. Percent Swine Operations for Non-Municipal Areas

	Percent of Land Area	Percent of Swine Operations
Majority African-American	36.46%	57.31%
Greater than 22% African-American	12.70%	19.69%
Less than 5% African-American	38.53%	8.92%
Less than 75.6%White	40.20%	66.31%
Above State Average Education Less than Ninth Grade	61.75%	84.73%
Above State Average Some High School No Diploma	70.06%	98.94%
Above State Average High School Graduates	25.97%	19.20%
Below State Average BS/BA	90.53%	84.69%
Greater than 25% of Families Below Poverty Level (<$12,500)	52.96%	82.33%
Greater than 65% of Families Making Below Average State Income (<$30,000)	42.83%	66.50%

The results from this analysis are very similar to the results for the entire state. This indicates that removing the municipal areas have little effect on the differences between percent area and percent of swine operations. The one change is in difference for Bachelors degree category. These results are displayed in figures 7 and 8. In this category, after the removal of the municipal block groups, there is a larger percentage of land area than swine operations. This seems to indicate that those areas with less than state average for bachelors' degree receive less swine operations than would be expected. After removal of municipal areas, the percentage of land with lower than state average for Bachelors degree increases, but the percentage of swine drops. This indicates a correlation between swine operations and high education areas.

This may be explained by commuting patterns around municipal areas. People commute further to work, so it is not unusual for urban professionals to live in rural areas. This could explain this anomalous result. The rest of the results match closely with the results for the entire state. There are no large discrepancies for any of the other variables.

Figure 7

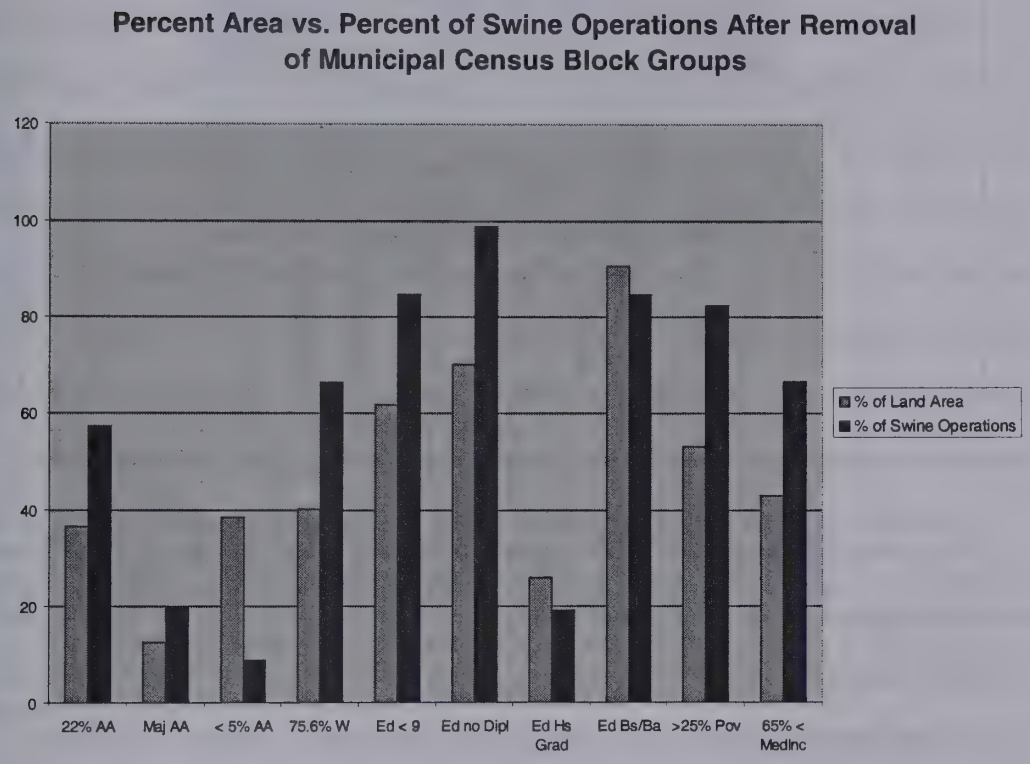
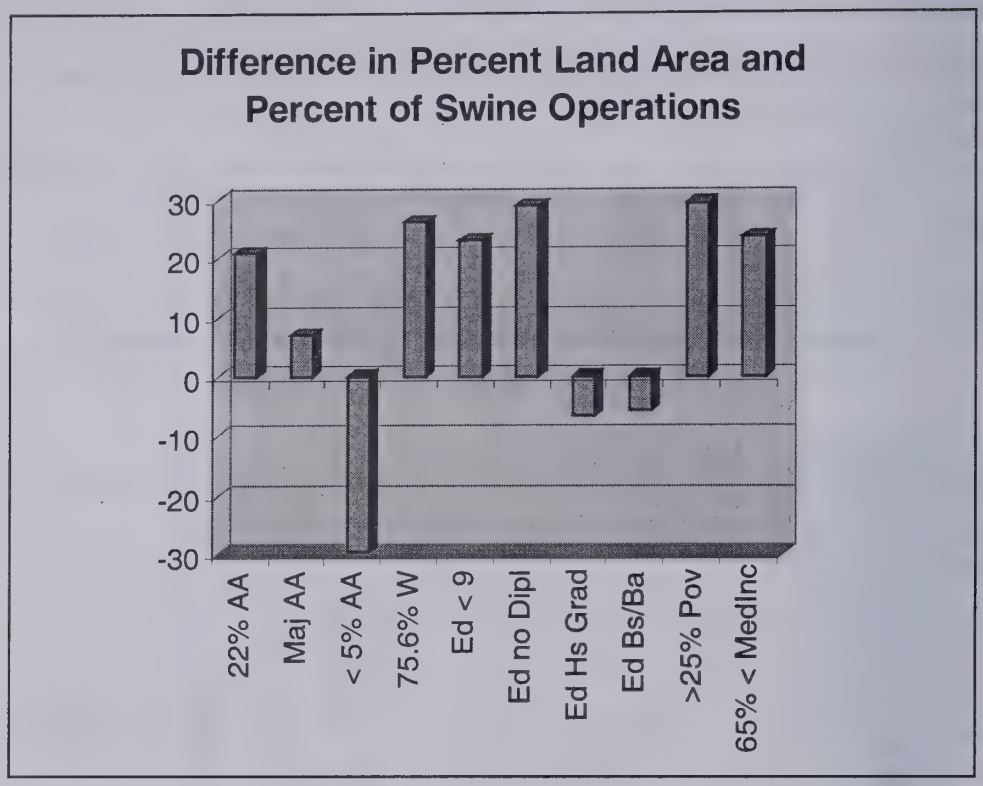


Figure 8



These results indicate that there is a basis for environmental equity concerns, and that industrial swine operations appear to locate disproportionately in low income, low education and high minority communities. Additionally, based on these preliminary analyses, there appears to be little difference in the results after removing the census block groups that fall within municipal boundaries. This seems to indicate that removing the urban areas has little effect on the overall percentages, which is counter-intuitive. It would seem that removing the municipal areas would have an effect on the amount of land occupied by each category but, this is not the case. This indicates that these low income, low education and high minority areas are distributed evenly among municipal boundaries and non-municipal areas. The results in this section are useful for visual purposes, but allow for limited conclusion. This analysis does not account for correlation between variables, such as various education levels and income levels. For example, an area that is low income may be also be low education due to economic factors, and this analysis does not account for this type of interaction. In order to account for this, further analyses are performed in the following sections.

Comparison of Block Groups with Swine Operations to Those Without

Entire State

The next analysis performed on the data was to compare the means from block groups with a swine operation to those block groups that do not have a swine operation. Map A-1 shows the North Carolina census block group boundaries, and also shows block groups with swine operations, and those without. This analysis will show if the means of the socioeconomic variables are significantly different from block groups with swine operations to those without. If there are no environmental inequities, then the means should not be significantly different. If the means are significantly different, then there is a possibility that there are environmental equity issues that need to be addressed. In order to compare the means a two-tailed t-test was used. The null hypothesis of this example is that, $B_0 = B_1$, where B_0 is the value census block groups with swine operations, and B_1 is values for census block groups without swine operations. In order to test the significance of the difference between the two values, a calculated t-statistic is compared to a critical t-statistic. If the calculated t-statistic is larger than the critical t, then the difference is significant. For this analysis, the critical t-value is 1.98, which is equivalent to a .05 probability level. This means that the null hypothesis can be rejected 95% of the time.

Table 4: Comparison of Means for North Carolina

	Census Block Groups with Swine Operations	Census Block Groups without Swine Operations	T-statistic
Percent African-American	28.91%	21.70%	4.19
Percent White	67.59%	75.33%	4.04
Percent Less then Ninth Grade Education	15.58%	11.82%	3.53
Percent Some High School	22.66%	18.68%	2.45
Percent High School Graduate	34.19%	29.03%	2.74
Percent with Associates Degree	5.98%	6.15%	.1414
Percent with Bachelors' Degree	5.38%	10.60%	4.30
Percent with Graduate Degree	2.07%	4.54%	3.1
Percent of Families in Poverty	28.10%	23.33%	2.59
Percent of Families Making Less than Median Income	63.63%	56.35%	3.57

Based on this table, all of the variables except for percent with an Associates' degree are significantly different across the two groups, which indicates possible inequities. The largest differences occur in the racial distributions, with both percent African-American and percent white having a 7% difference. The other variables also show differences in their means. Income variables also differ significantly across census block groups with and without swine operations. This table depicts variances in socioeconomic variables of census divisions. According to these calculations, census divisions with swine operations had lower education, lower income and higher percentages of minority communities. Based on this information for the entire state, it appears that lower income, education levels and high minority areas do receive a higher exposure to the environmental externalities associated with industrial swine operations. These calculations of t-statistics seem to indicate that for the entire state, income and minority levels seem to differ the most strongly between block groups with swine operations and those without, however, education levels are also significantly different.

Areas Outside of Municipal Boundaries

In order to test for influence by areas that could not house hog farms, the analysis was repeated for the entire state, with those block groups that were mostly within a municipal boundary removed. The results from this analysis are displayed in table 5.

Table 5 Comparison of Means for Non-Municipal Areas

	Census Block Groups with Swine Operations	Census Block Groups without Swine Operations	T-statistic
Percent African-American	29.02%	12.75%	10.29
Percent White	67.47%	75.20%	4.54
Percent Less then Ninth Grade Education	15.71%	11.49%	2.95
Percent Some High School	22.79%	17.56%	3.09
Percent High School Graduate	34.27%	28.58%	2.86
Percent with Associates Degree	5.98%	5.80%	.1809
Percent with Bachelors' Degree	5.21%	7.97%	2.74
Percent with Graduate Degree	2.00%	3.20%	1.62
Percent of Families in Poverty	28.20%	19.23%	5.07
Percent of Families Making Less than Median Income	63.79%	49.08%	6.76

In this analysis, all of the variables showed significant differences in mean percentages between census block groups with a swine operation and census block groups without one. Once again, the strongest differences were for racial variables, there is a difference of 16.27 between the two means for percent African-American. The mean of percent African-American for census block groups with swine operations is double that of census block groups without. Income variables also are very different between the groups. The differences between the education levels are not as large, and the differences for two of the measures of education are not significantly different. Percent with an Associate's Degree and percent with a graduate degree do not differ significantly from block groups with swine operations to those without. Based on these comparison of means tests, racial and income data appear to be the strongest indicators of environmental

equity issues. Based on this analysis, census divisions with swine operations are expected to have higher percentages of minority populations, low income residents and residents with lower education levels than those without.

Although these results display striking trends, in education, income and minority status in census block groups with swine operations, there are limitations to this method of analysis that may skew the results. This method does not account for correlation among the variables. Another limitation of this method is that it does not take into account all of the variables that could possibly be influencing the analysis. For example, land cost, which is a variable for which data was not available on the state level, could have an influence on the location of swine operations. For example, cheap land may attract hog farmers, and low-income families, because that is the only land that they both can afford. This correlation is not accounted for with a comparison of means test. This test included all of the data that could be appropriate, which could be obtained on this level of analysis. The results support the hypothesis that there are some inequities of siting hog farms. In order to explore this in a more comprehensive manner a logistic regression was performed.

Logistic Regression Analysis

Entire State

The first analysis performed using logistic regression regressed percent white, percent education less than ninth grade, percent not high school graduate, percent high school graduate, percent of people with a bachelors degree, percent of families in poverty and percent of families making below the state median income against pig farms. Pig farms was a dependent variable that equaled one if there was a swine operation in the census block group and zero if there was not one. Percent black was left out due to the strong relationship with percent white. The variable percent white was used to determine if the odds of having a swine operation increase as the percent white decreases. If this is the case, then the coefficient will be negative and significant. Also, some of the education levels were left out, because including every

category in the analysis is unnecessary. If swine operations do locate in low education areas, then less than ninth grade and not high school graduate population will increase with the likelihood of having a hog farm in that block group. If there is environmental inequities, then it can be expected that the income variables will have a positive coefficient that is statistically significant. This means that as poverty levels increase the odds of having a hog farm in that census division also increases. Equation 1 and table 6 show the results from the first logistic regression. For this set of regressions, the sample size was 5704.

Original Equation

Eqn. 1: Logit (Swine Operation) = -3.3649 - .0066Percent White + .0349Percent Education Less than Ninth Grade + .0147 Percent Some High School + .0513 Percent High School Graduate - .0505Percent with Bachelors Degree – .0047Percent in Poverty - .0026Percent Below Median Income

Table 6 Logit Regression Results form Eqn. 1

Variable	coefficient	Chi-squared	P > chi-squared
Percent White	-.0066	15.6501	.0001
Percent < 9th Grade	.0349	22.6269	.0001
Percent Some HS no Diploma	.0147	3.9936	.0457
Percent HS Grad	.0513	50.5131	.0001
Percent BSBA	-.0505	13.2643	.0003
Percent in Poverty	-.0047	.8294	.3624
Percent Below Median Income	-.0026	.3259	.5681

Based on these results, there are some variables that return non-significant results. Significance for this analysis is going to be examined for both the 90% and 99% confidence levels. The next step is to eliminate the variables that are non-significant, in order to get an equation with all significant variables. This is achieved by dropping the variables one at a time, because dropping one variable can have an impact on the significance of other coefficients. Dropping variables to achieve a 90% level of significance, the results in equation 2 and table 7 are achieved.

At 90% Level of Significance

Eqn. 2: Logit (Swine Operation) = -3.4699 - .0065Percent White + .0347Percent Education Less Than Ninth Grade + .0144Percent Some High School + .0511 Percent High School Graduate - .0495Percent with Bachelors' Degree - .0066Percent Poverty

Table 7 Logit Regression Results from Equation 2

Variable	coefficient	Chi-squared	P > chi-squared
Percent White	.0065	47.5489	.0001
Percent < 9^{th} Grade	.0347	22.4435	.0001
Percent Some HS no Diploma	.0144	3.8465	.0498
Percent HS Grad	.0511	50.2175	.0001
Percent BSBA	-.0495	12.9493	.0003
Percent in Poverty	-.0066	2.7441	.0976

First of all, percent white is negative and significant. This means that as the white population decreases, the log odds of having a hog farm in the census division increase significantly. The results for percent less than ninth grade, percent with no diploma and percent with Bachelors' degree also make sense if there are environmental equity issues. As percent of people with low education increase, then the log odds of having a swine operation increase, and as the percentage of people with high education decline, the log odds increase. All of these results indicate that there may be some sort of environmental inequity. An anomalous result is the fact that as percent of families in poverty declines, the log odds of hosting a hog farm increase. This seems counter-intuitive to all of the other results. This result may not be as valid as the others, due to its high p-value. The other strange result is the fact that as percent of people with high school education increases, the log odds of having a swine operation increase. This can be explained in a couple of different ways. First, this study considers high school graduate to be a measure of high education levels, this may be a false assumption. If high school graduate is considered a low education level, then the result makes more sense. Increasing percent of high school graduates is taken with a decrease in college graduation, so again, high school graduation does not denote higher education levels. The next analysis shows the logit regression for the 99% level of confidence. The results are shown in equation 3 and table 8.

At 99% Level of Significance-

Eqn. 3 – Logit (Swine Operation) = -3.0079 - .0059Percent White + .0280 Percent Education Less than Ninth Grade + .0454Percent High School Graduate - .0629 Percent with Bachelors Degree

Table 8 Regression Results from Eqn. 3

Variable	Coefficient	Chi-squared	P > chi-squared
Percent White	-.0059	16.791	.0001
Percent < 9^{th} Grade	.0280	18.2482	.0001
Percent HS Grad	.0454	53.2122	.0001
Percent BSBA	-.0629	32.2921	.0001

For this analysis, all of the coefficients indicate some sort of environmental equity issue. Based on this analysis as levels of low education increase, high education decreases, and percent white population increase in a block group, then the log odds of a swine operation being in that block group increase significantly. Contrary to earlier analyses, income does not appear to be a significant factor in determining whether a block group will have a swine operation. The next step of this analysis is to determine whether or not removing the municipal areas has an effect on which variables indicate the presence of an industrial swine operation.

Non Municipal Areas

The first analysis is similar to the first logistic regression performed. In this case there are simply fewer block groups involved in the analysis, in this case the sample size is 3625. The results are shown in equation 4 and table 9.

Original Equation

Eqn. 4 – Logit (Swine Operation) = -1.4046 - .0216Percent White + .00006Percent Less than Ninth Grade - .0014Percent Not HS Graduate + .0329Percent High School Graduate - .0638Percent Bachelors' Degree + .0180Percent in Poverty + .0089Percent Population Below Median Income

Table 9 Regression Results from Eqn. 4

Variable	coefficient	Chi-squared	P > chi-squared
Percent White	-.0216	106.6515	.0001
Percent < 9th Grade	.00006	.00004	.9946
Percent Some HS no Diploma	-.0014	.0241	.8766
Percent HS Grad	.0329	13.6348	.0002
Percent BSBA	-.0638	13.9821	.0002
Percent in Poverty	.0180	6.1736	.0130
Percent Below Median Income	.0089	2.20	.1380

Again for this analysis, there are several variables that are not significant. These variables were removed until the analysis was significant at the 90% level of confidence. This also was the equation that is significant at the 99% level of confidence. The results are shown in equation 5 and table 10.

At 99% Level of Significance (identical to 90% Level of Significance)

Eqn 5 – Logit (Swine Operation) = -1.030 - .0218Percent White + .0330Percent High School Graduate - .0687BSA Percent with Bachelors' Degree + .0250Percent in Poverty

Table 10 Regression Results from Eqn. 5

Variable	coefficient	Chi-squared	P > chi-squared
Percent White	-.0218	113.112	.0001
Percent HS Grad	.0330	20.8609	.0001
Percent BSBA	-.0687	30.1502	.0001
Percent in Poverty	.0250	23.0388	.0001

These results all indicate that there is not environmental equity. Since the coefficients for percent white and percent with a Bachelors' degree are both negative, they indicate that as they decrease, the log odds of having a swine operation increase. Percent high school graduate and percent of families in poverty are positive, so as they increase, the likelihood of having a swine operation in that block group increases. All of these results are consistent with the hypothesized results that would indicate environmental inequities. It is interesting that removing the municipal areas changes the indicators for hog farm location. When considering just those census block groups not within municipal boundaries, then education and income

appear to be lower, while minority percentage is higher. This indicates that both for the entire state and for just the non-municipal areas, socioeconomic variables can predict location of industrial swine operations.

Inspection Analysis

The final analysis performed for this project involved inspections of swine operations. This data was compiled on the county level and was used in conjunction with county census data. This database composed of each county's socioeconomic variables, and the inspection data for each county was used to perform a multiple regression analysis. In contrast to the earlier logistical regressions, this regression is ordinary least squares, since the dependent variable is continuous. All of the socioeconomic variables were regressed against percent of swine operations inspected, percent of violations, and percent of water quality violations. The results from this analysis are displayed in table 11. The goal of this analysis is to test for procedural equity. If there is no procedural equity, then correlation could be expected between number of inspections for counties with high education, income and white population. Also, if there are environmental inequities, then the expected results would be a relationship between high levels of minority population, low-income areas, and low education and the number of operations per county can be expected.

Table 11 Multiple Regression for Procedural Equity Analysis

	R-squared	Adjusted R-squared	Probability > F Stat
Percent Inspected	.1045	0	.5188
% Violations	.2205	.0371	.3270
%Water Quality Violations	.1706	0	.6096

The results for these analyses all return a very high probability that the f-statistic is greater than a critical f-statistic, which means that the results for the analysis are not significant. There are a number of possible explanations for this not returning a significant result. First of all, this could mean that there is no procedural inequity. Even though the findings of this report indicate that there is not geographical equity, that does not mean that there would also be procedural inequity. Procedural equity is based on regulatory enforcement and creation of laws, and is completely separate from geographic equity issues.

The next possible solution is that the data set used was inappropriate. There could be a variety of possible reasons why this data would not be appropriate for this analysis. First of all, it could be caused by different scales. The analysis performed so far has determined that there are clearly environmental equity issues on the block group level. On the county level, all of these issues could be "smoothed over", because it is such a large area. This could result in the non-significant results above. Another possible explanation is the discrepancy in number of counties. Many of the counties had no swine operations, which may have caused the results. In future research, this could be tested by eliminating all of the counties with no swine operations and performing the analysis again. A final consideration is that in all the counties with swine operations, there were high occurrences of violations. Only 27% of all the farms have been inspected (SELC, August 7), when all of the inspections have been performed, the results could be very different. The results from this analysis are inconclusive, and should be analyzed again in the future to determine if there are procedural inequities

Conclusions

This analysis revealed many important environmental equity issues within the North Carolina swine industry. Through several different analytical processes, clear variances from environmental equity were found. Of the four different methods chosen, all except the county level inspection analysis showed environmental inequities.

- The initial analysis performed was a comparison between the percent of area occupied by above state averages of certain socioeconomic variables. This analysis showed that there was a discrepancy between the amount of land occupied by low income, education and high minority areas, and the percent of swine operations in those areas. The only variable that seemed not to show environmental inequity was percent high school graduate. This provided preliminary indications that there may be environmental equity issues in the North Carolina swine industry.

- The next analysis was a comparison of means for these variables for block groups with swine operations and those without. The initial analysis showed for the entire state that all of the variables were significantly different except for percent with Associates' degree. All of these differences indicated a tendency towards environmental inequity. The next analysis was for the state with the municipal areas removed. This analysis indicates that on average the block groups with swine operation had lower education, income and higher minority than block groups that did not have a swine operation. This analysis provided further evidence of environmental inequity.

- Another analysis was a logistic regression, to determine if socioeconomic variables showed a significant relationship with the explanatory variable, which in this case was whether or not the block group had an industrial swine operation. This analysis also indicated that as low education and percent minority increased then the odds of having a swine operation also increased the entire state. For the non-municipal areas as percent minority, low education and low income increased, the odds of having a swine operation also increased. This analysis suggests that several of these variables are significant in explaining whether a swine operation is in a block group.

- The final analysis performed was a multiple regression on the percent of inspections and percent of violations for swine operations, on a county level. This analysis suggested that there was no evidence of procedural inequity.

Based on these analyses, a case can be made that low income, low education, and high minority areas are unequally impacted by industrial swine operations. These analyses have not examined the cause of this discrepancy, and cannot provide a causative link. However, it is clear that certain groups are exposed to higher levels of exposure to the dangers caused by these industrial swine operations. This project provides evidence that on a census block group level, there are environmental injustices in the location of swine operations in North Carolina. Future research needs to be done on this issue, using other

data layers in the analysis, such as land use and land cover, or tax maps. These data layers could add to the analysis, and further analysis could indicate cause. For example, tax maps could determine if hog farms are located in the cheapest land areas. Another consideration for future research would be to analyze a smaller area. This analysis examined the environmental justice issues for the entire state, it may be appropriate to examine a smaller area, such as the eastern part of the state, where swine operations are concentrated. This analysis may explain the strong correlation between racial percentages and swine operations, since the eastern part of the state has higher percentages of African-American, but it does not explain the correlation between low education and low-income areas. These areas are distributed evenly across the state, so the fact that swine operations are concentrated in the east will have little effect on the analysis. Additionally, in depth temporal analysis could determine whether the swine operations were in the same locations, and if those locations always had the same socioeconomic characteristics. These further analyses could add insight to the debate of whether or not the location of industrial swine operations in North Carolina are equitable.

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Appendix

Maps

North Carolina Census Block Groups

Census Boundaries

w/ Swine Operations

No Swine Operations

SCALE 1:3196949

0 50000 100000 150000 200000

METERS

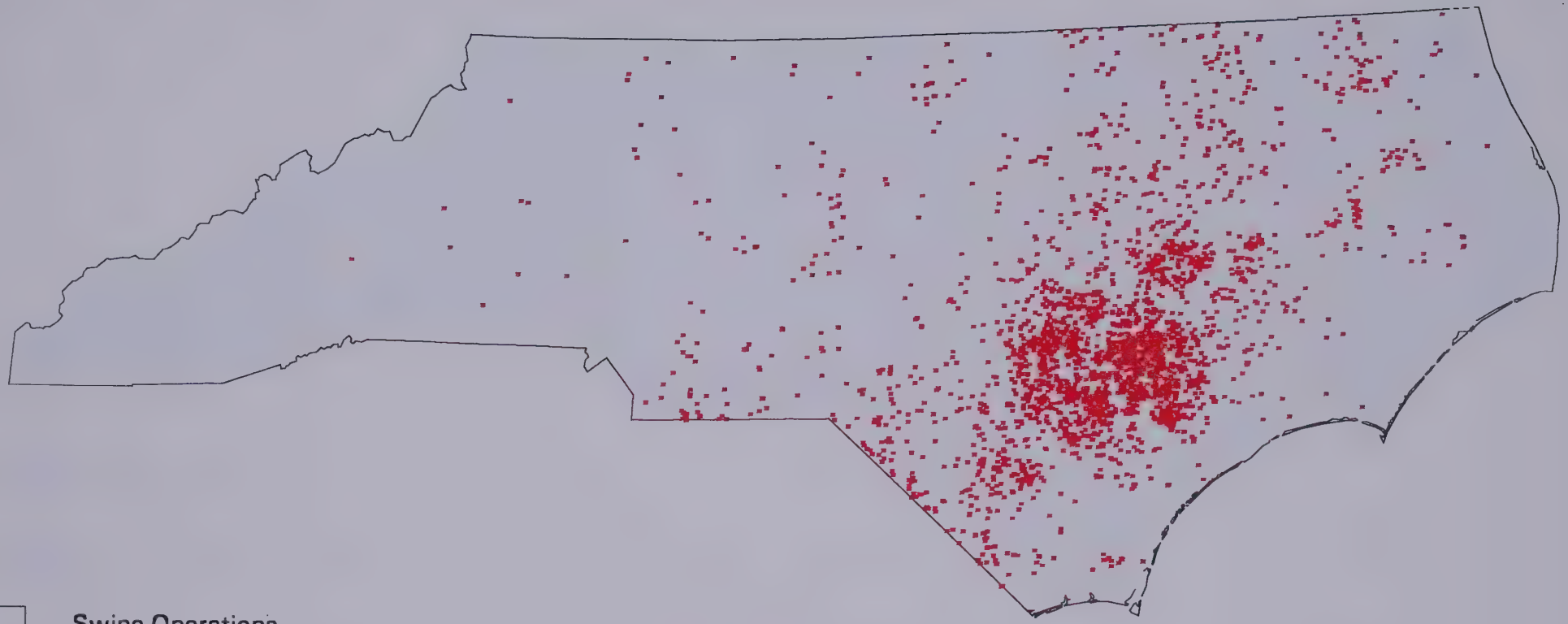
N

W E

S

A-1

North Carolina Industrial Swine Operations



Swine Operations

SCALE 1:3138716

0 50000 100000 150000 200000

METERS

N

W E

S

A-2

Block Groups and Municipal Areas

SCALE 1:3160621

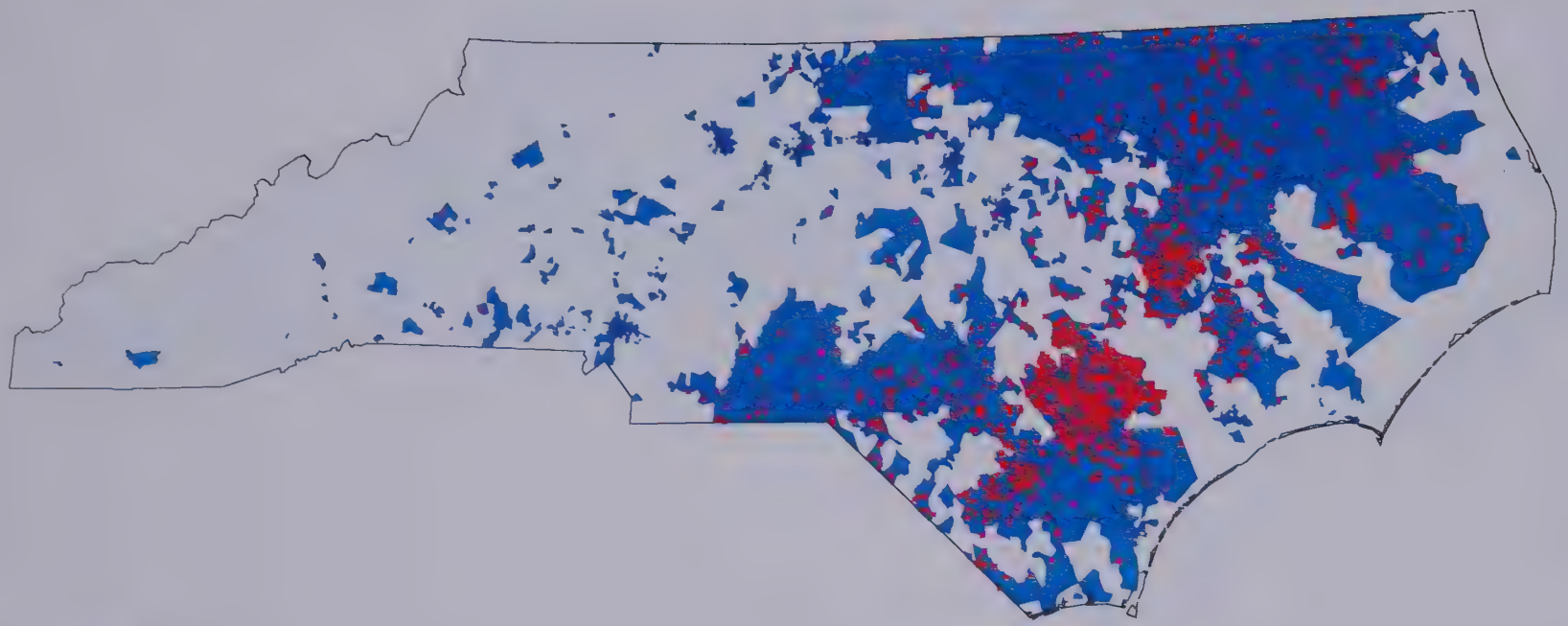
0 50000 100000 150000 200000

METERS

N
W E
S

A-3

Swine Operations in Block Groups with Above State Average African-American Population



Block Group

Swine Operation

A.S.A African-American

SCALE 1:3541163

0 50000 100000 150000 200000

METERS

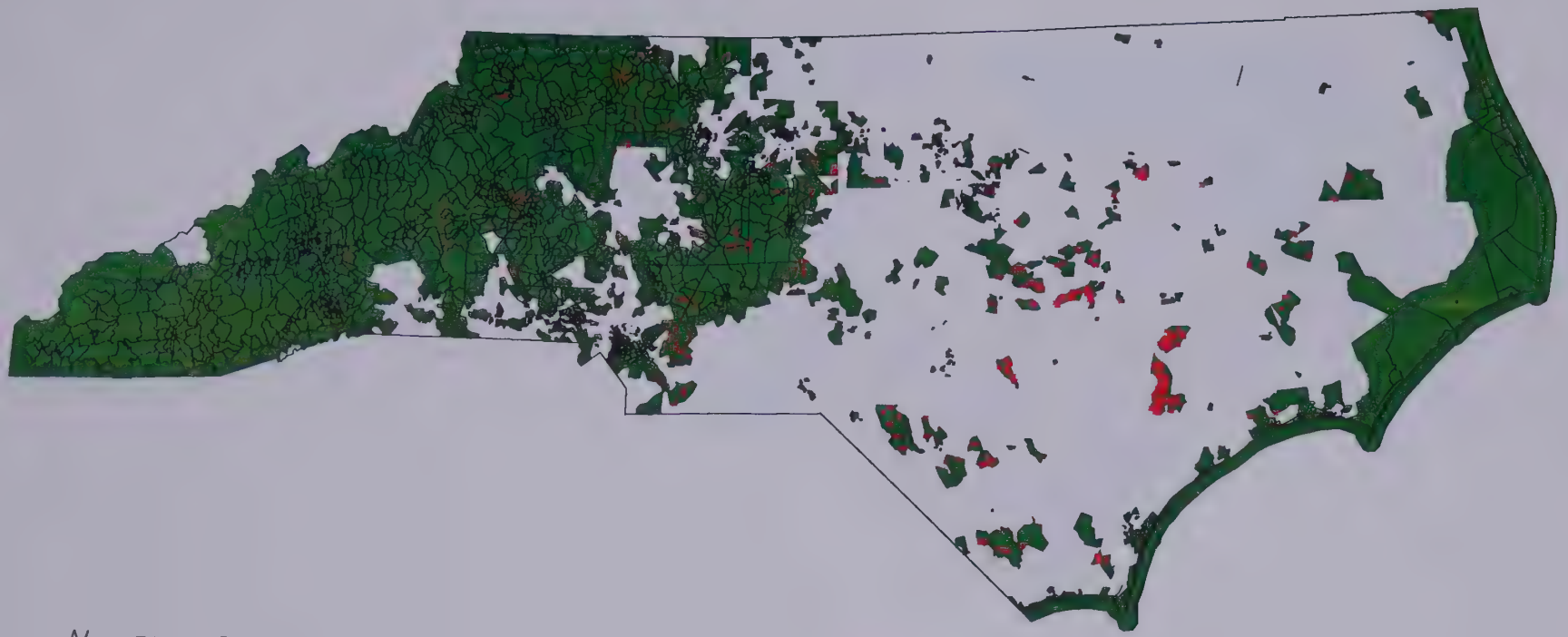
N

W E

S

A-4

Swine Operations in Block Groups with Less than 5 Percent African-American



N Block Group

Swine Operation

< 5 Percent Black

SCALE 1:3541163

0 50000 100000 150000 200000

METERS

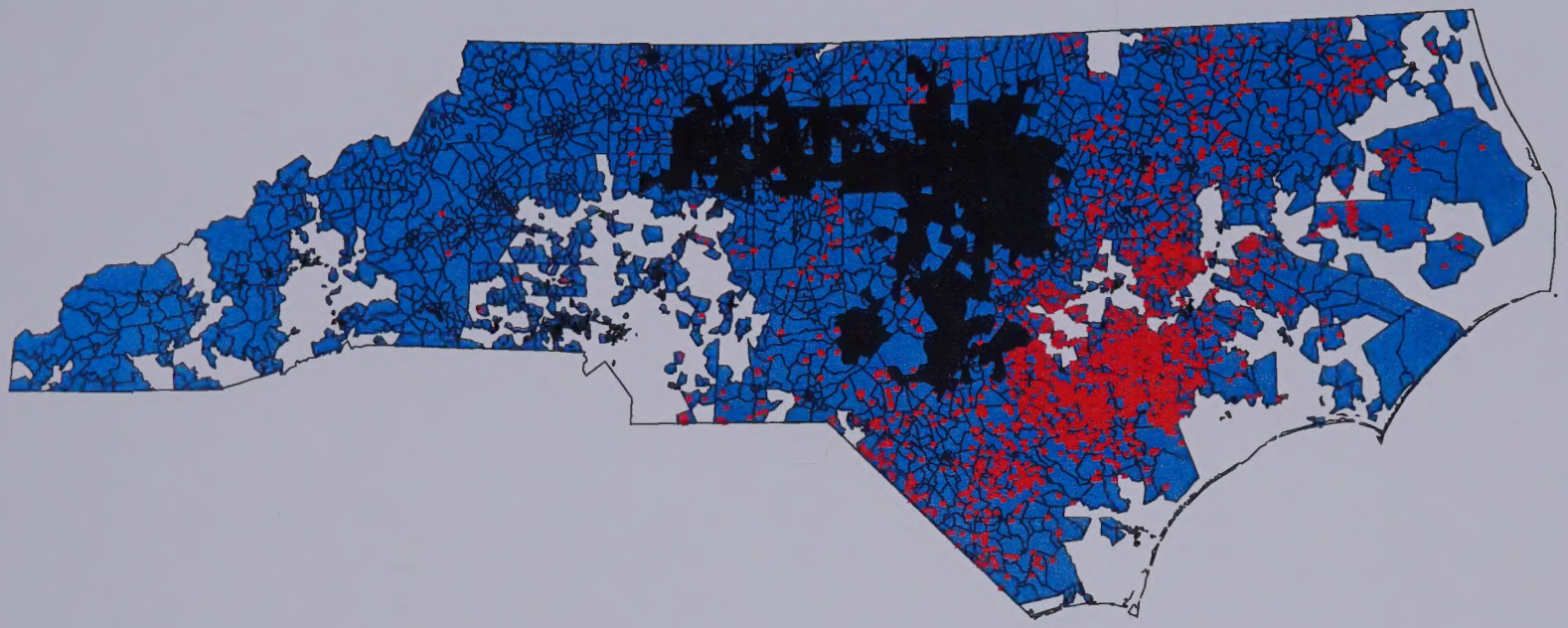
N

W E

S

A-5

Swine Operations in Block Groups with Below State Average Education Levels



N

Block Group

Swine Operation

A.S.A < Ninth Grade

SCALE 1:3541163

0 50000 100000 150000 200000

METERS

N

W E

S

A-7